Clinical Linkages: IAIMS at the University of Utah

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The IAIMS project at the University of Utah has focused on clinical linkages to facilitate the research, teaching, and service mission of the Medical Center. The planning phase focused on the relationship among the users and providers of the system and developed a scenario describing the professor and clinical clerk making rounds in the bedside setting. The prototype Health Evaluation through Logical Processes (HELP) system brings together three sources necessary to solve a medical problem: the patient database, the medical literature, and an expert in the subject. Microcomputers provide access to the HELP system and a complementary literature knowledge database.

The goal of IAIMS at the University of Utah is to develop and implement an information management organization and an information handling capacity to facilitate the research, teaching, and service mission of the Medical Center. Supported in part by the National Library of Medicine, this amibitious undertaking began with a formal planning phase, and is now in its second phase, prototype development.

Planning

Identification of functional specifications for the system depended heavily on the perceived relationships among the users and providers of information which the system was designed to serve. These specifications were defined to include sharing data, particularly patient data; developing and sharing knowledge bases; and assessing medical literature and bibliographic files.

The scenario which guided much of the planning centered around a professor and a clinical clerk making rounds in a bedside setting. The system was planned to allow the teacher or student to access easily, through a computer terminal, patient data in a variety of forms. These included not only raw data such as numbers for laboratory values, but derived data and interpretations of data based on criteria in a knowledge base.

Plans further called for the student or professor to be able to recall data to patients similar to the one in the bed. Such an activity was designed to provide the student with a whole new dimension in understanding the disease or other problems of the patient at hand. Many of the powerful resources needed to achieve this were already operational at Utah and commercially available to other academic health centers. The refinements needed to achieve this scenarios in a real working environment were to serve as one major focus of the prototype development now well underway.

For clinical linkages to be established and to function effectively, the planning process involved representatives of the key units, including the University Hospital, the Eccles Library, the School of Medicine, and the Colleges of Nursing, Pharmacy, and Health. Policy issues revolved around defining appropriate means for sharing costs or payment for information within data bases. Real instances forced the IAIMS group to address and to resolve these issues early in the project.

Prototype Development

Now in the third year of prototype development, IAIMS at the University of Utah has completed the integrated library system for the Eccles Health Sciences Library, including online access to the complete catalog of library holdings. This is serving as the base for important new services to users in four colleges (Medicine, Nursing, Health, and Pharmacy) on the medical campus. Additional development and implementation efforts have targeted innovative components of a prototype integrated information system for the Medical Center. These efforts have focused on structuring medical information in the form of models helpful in solving problems in the clinical setting.

Information needed to solve a medical problem can be obtained from three sources: a patient database, the medical literature, and an expert in the subject. The prototype development built on existing computer resources to create a system which could facilitate access to all three of these information sources for any user with a clinical problem to solve. As part of IAIMS, the University of Utah implemented and tested a system for servicing the query function for two types of users: researchers and developers of medical decision support technology and medical students during their third year clerkship in internal medicine.

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Activities were directed toward improving access to information about existing models of decision support technology (DST) and facilitating the teaching of internal medicine as part of a third year clinical clerkship using a patient database coupled to an operational decision support system.

Health Evaluation through Logical Processes (HELP)

Clinical linkages in IAIMS are realized through the HELP system. The HELP system is a large computer based hospital information system developed by the Department of Medical Informatics of the University of Utah for the LDS hospital in Salt Lake City and subsequently installed at the University Medical Center. The HELP system is a complete medical information environment, in which patient data is collected on a routine basis from all parts of the hospital and is made available to support these knowledge base development projects. In return, the system interpretations enrich the patient database and further provide for data accuracy and validation. Thus, in the clinical setting, the analysis of patient observations and interpretations of those observations provides a valuable source of information in addition to literature review and expert consultations.

Building a decision model involves restructuring knowledge in a particular medical speciality into an explicit form understandable to the computer. This usually requires long periods of testing against real case material with many revisions before an accurate representation could evolve. The HELP system, a complete information system, has been built around an extensive clinical database which serves as an alternative source of information in the development of the HELP knowledge base. A set of high level tools was created to access this database; these tools effectively streamline the design phase of query generation while protecting the user from the complexities of an active patient database.

HELP thus supports the user in acquiring data and in implementing logic. A time oriented database, it consists of two elements: a long term abstract of demographic and clinical information retained for possible readmissions of the patient and a short term collection of all data gathered during the current hospital admission.

The data available in the clinical database include drugs prescribed, laboratory data, x-ray and ECG interpretations, respiratory therapy data, biopsies, microbiology data, and other clinical information. Efforts are currently being made to integrate physician and patient derived data including history and physical examination into the database; a computer administered history for hospitalized pulmonary patients has been successfully tested.

All data items are stored in coded form, thus allowing for the data to be manipulated in decision logic. A computer based data dictionary called PTXT (pointer to text), containing some 70,000 terms, is evoked either for storing or for reviewing patient data. In addition to the text, key words are defined offering an easier access to the dictionary. The coding scheme of the dictionary follows a tree structure with terms arranged in a hierarchy that reflects knowledge about a domain. The dictionary also contains other medical nomenclatures such as ICD-9 and SNOMED codes.

HELP contains a separate knowledge base consisting of the logic for a group of medical decisions that are triggered by the system when a prespecified set of clinical circumstances occurs. These medical algorithms or sets of rules are called HELP frames and are stored in a modular knowledge base integrated into the medical information system, where over 2,000 different HELP frames are currently operational. Multiple decision models are supported in the HELP system to allow flexible modeling of medical knowledge.

HELP's comprehensive clinical database constitutes a rich source of information. For the medical decision author, the availability of this resource offers assistance not only in defining the logic for the frames but also in proving a setting to test the knowledge frames produced. In other words, patient data may be used as often as needed to refine, confirm, or deny any clinical decision frames under development.

Tools enhance the expert systems knowledge base. Among these are an information retrieval program, STRATO, designed to ensure ease of access to the clinical database while preserving a powerful means to describe the information searched. An important part of STRATO is to provide an interface between the mainframe based system on TANDEM to powerful microcomputer based programs for database analysis, including MacHELP on Macintosh computers.

Whether accessed from the host computer or remote desktop microcomputers, the STRATO program retrieves and stratifies HELP patient database information for subsequent analysis. STRATO prompts the user to define his selection criteria, process the query against the patient database, and structure the results in the form of populations (list of patient numbers), valuables (a value for each patient) and time series (for each patient, at each time index, a set of values).

The power of the system is enriched by linking microcomputers to the mainframe. Users can pursue investigations using their own data manipulation packages at their own workstations. The coupling of the rich database with convenient graphic routines and statistical analysis programs makes patient observations a direct and effective pathway to medical knowledge. The link to the personal workstation stimulates the back and forth approach from data extraction to data description, effectively shortening the time between idea conception and test.

Furthermore, carrying out these activities at remote workstations gives a larger number of users in the research community access to the HELP patient database without requiring from them any specific experience with the hospital computer or the HELP system syntax—and without overloading the clinical system.

The development of expert systems for the HELP system is a major focus of the Department of Medical Informatics at the University of Utah. For that goal three sources of

information are used conjointly: expert experience, literature review, and the patient data. All sources contribute to suggesting of confirming or rejecting relationships between medical variables as well as estimating specificities and sensitivities of findings within a disease context. Several knowledge development projects are currently active in the fields of orthopedics, hematology, pharmacy, pain management, and primary care medicine.

In each of these knowledge production projects, the STRATO programs is being used to provide the knowledge engineering team with pertinent information from patient data as well as prospective evaluation of the performance of the knowledge frames developed. Work in these areas has contributed significantly to the development of a knowledge engineering system (KES), which will allow for the dispersion of the techniques refined at Utah to other academic health centers in the United States.

The HELP system is complemented by the Macintosh based ILIAD program, which grants students access to a literature knowledge database of close to 1500 journal articles and monographs selected by experts in internal medicine. With a fully automated library and remote access to references, students may also build their own reprint files using ILIAD; these files can serve as base for building decision models derived from the medical literature.

Available at all hours through microcomputers located on the medicine wards at the University of Utah, ILIAD allows the use of natural, imprecise words as search terms, in combinations using 'and' and 'or' arrangements to express a concept to be used as a query. A powerful, transparent system known as "relations" translates these nonspecific terms to perform powerful searches. This system broadens the list of items retrieved and removes the constraint of requiring the searcher to specify the exact key word used by the person who stored the item. As a result, relations can be entered after the fact; they can be used interactively at retrieve time; they can be modified and expanded by experts to assist the nonexpert query; and a term may be part of more than one relation, allowing the database to express a variety of hierarchial structures.

The software package of computing tools making ILIAD and HELP available to students is called ODYSSEY, which shares the relations approach. Based on microcomputers linked to the hospital mainframe hospital, Odyssey provides access to both systems. A third knowledge base, a hypertext book of internal medicine, is now under development.

Integration

Other activities not directly supported by the National Library of Medicine are also vital to the building of a modern integrated information system on the campus. Among these are completing the installation of the HELP system throughout the hospital and responding to the requests for expanded services; installing a network for basic science researchers who share programs and databases primarily around genetics and genealogy; and coordinating efforts to install local area networks within most departments for both administrative and research purposes.

Now in the third year of its grant for prototype development, the IAIMS project at Utah continues to be powerful force for integration. The benefits of IAIMS are on the wards and in the labs, integrating the knowledge bases upon which clinical care is based.

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